

# Shock



## Objectives:

- DEFINE OF SHOCK
- IDENTIFY THE SIGN AND SYMPTOMS OF SHOCK
- IDENTIFY DIFFERENT CLASSIFICATION OF SHOCK
- DEFINE MULTI ORGAN DYSFUNCTION SYNDROME
- OBSTRUCTIVE
- HYPOVOLEMIA
- CARDIOGENIC
- DISTRIBUTIVE
- DEMONSTRATE AN UNDERSTANDING OF SHOCK PATHOPHYSIOLOGY
- IDENTIFY THE EFFECT OF SHOCK ON HEAMODYNAMICS.
- INITIATE A MANAGEMENT PLAN TO MANAGE SHOCK
- IDENTIFY TREATMENT GOALS
- DEVELOP INITIAL PLAN TO REACH THE TREATMENT GOALS

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# Shock

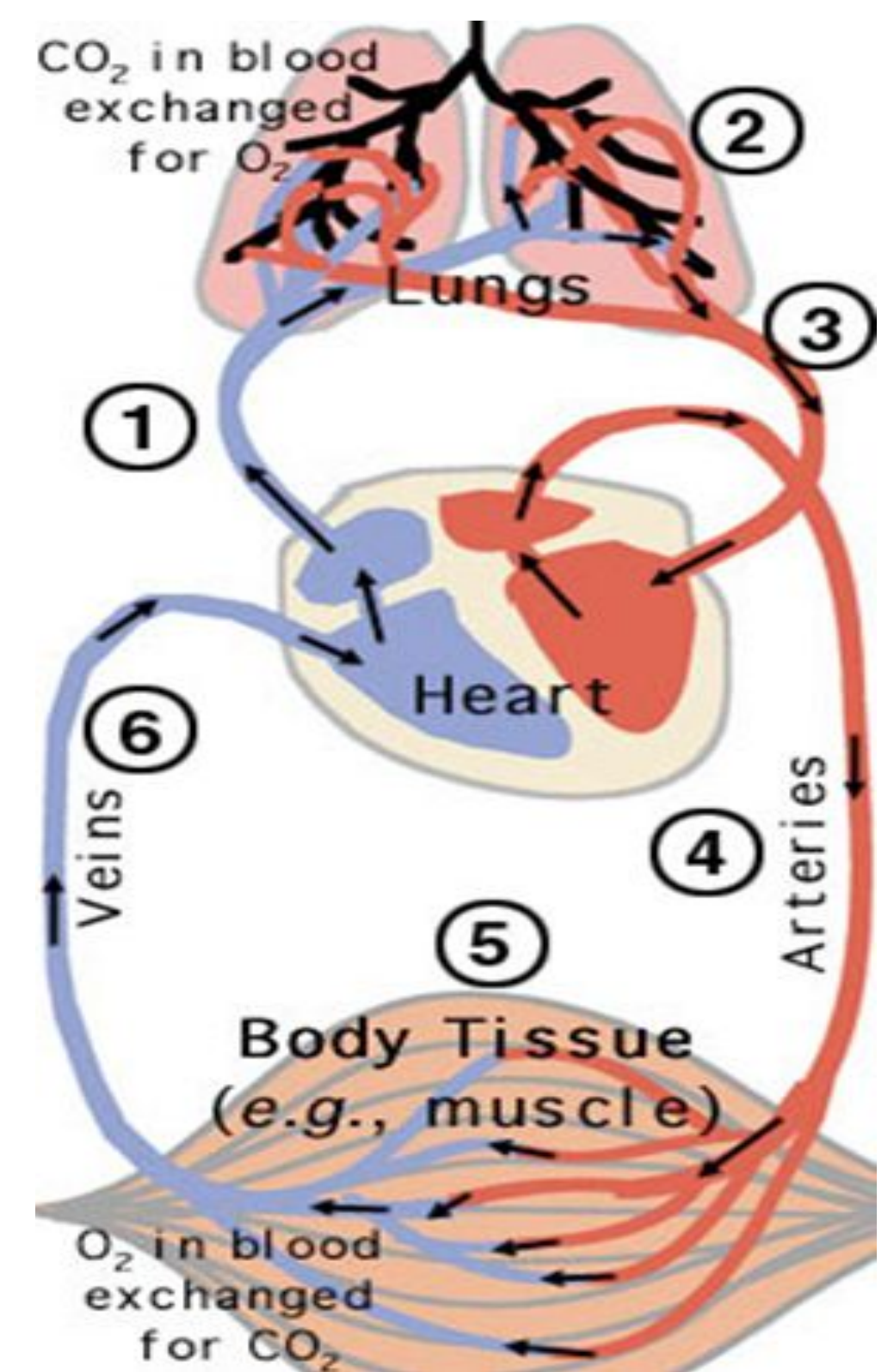
## What is shock?

- Inadequate oxygen delivery to meet metabolic demand. Taking this definition into consideration: shock can occur in normal blood pressure, conversely a patient can be hypotensive but not in shock.
- Results in global tissue hypoperfusion and metabolic acidosis
- Shock can occur with a normal blood pressure, & hypotension can occur without shock.
- Oxygen delivery is the function of the circulatory system.
- This system is basically\*:

Pump (heart)

Pipes (vessels)

Solution (blood)



\*Failure in any of these can result in different shock types

- Needs to function at adequate depends on the individual 'not a set number for all' ie: in some people 100/70 is enough while in others 120/80 is not. pressure, volume and o<sub>2</sub> carrying capacity (if you replace blood by water shock will happen because water don't have that carrying capacity), At any given moment , 30% of your vessels are closed; you don't perfuse all tissues ate the same time at the same level;eg: muscles don't require much supply in comparison to splanchenic during eating. Sudden opening of all vessels causes shock (anaphylactic shock).

## Understanding Shock

- Inadequate systemic oxygen delivery results in hypoxia activates autonomic responses (1st thing to be activated) to maintain systemic oxygen delivery. With the first sign of shock the bodey reacts by vasoconstriction, increase in cardiac output and water conservation

### Sympathetic Nervous System

- NE, epinephrine, dopamine, and cortisol release- Causes vasoconstriction, increase in HR, and increase of cardiac contractility (cardiac output)

### Renin-Angiotensin Axis

- Water & sodium conservation & vasoconstriction
- Increase in blood volume & blood pressure

\*When body senses less O<sub>2</sub> it tries to alarm us by sympathetic activation to make you feel anxious and to increase heart rate, sometimes this stimulation is enough and sometimes damage might happen.

# Understanding Shock

- Cellular responses to decreased systemic oxygen delivery
  - ATP depletion (cell can't make when cells don't receive enough O<sub>2</sub>) → ion pump dysfunction
  - Cellular edema ( normally Na/K pump will remove excess Na<sup>+</sup> however in the case of pump dysfunction Na influx will continue drawing water with it.)
  - Hydrolysis of cellular membranes and cellular death  
(when cells die it releases mediators and tissue factors and get activation of coagulation, platelets pumping and then Disseminated Intravascular Coagulation (DIC))
- The body tries to maintain vital organs: cerebral and cardiac perfusion
  - Vasoconstriction of splanchnic, musculoskeletal, and renal blood flow to shunt blood, brain & heart
- Global cellular reliance on anaerobic glycolysis and increased lactate production.  
(Aerobic glycolysis produces almost 38 ATP while anaerobic glycolysis produces 2 ATPs only)
- Systemic metabolic lactic acidosis this indicated the body is performing anaerobic glycolysis, meaning no O<sub>2</sub> is available for the cells with subsequent cell death, some patients will die from shock while lactate is normal, since the cells are too sick to attempt anaerobic glycolysis. Eg; 80 yrs old lady.

## Multi-organ Dysfunction Syndrome (MODS):

Ultimately, the cells are not working, no O<sub>2</sub>, cellular oedema, cellular death & cellular dysfunction leading to **Organ Dysfunction**.

- Progression of physiologic effects as shock ensues

Cardiac depression

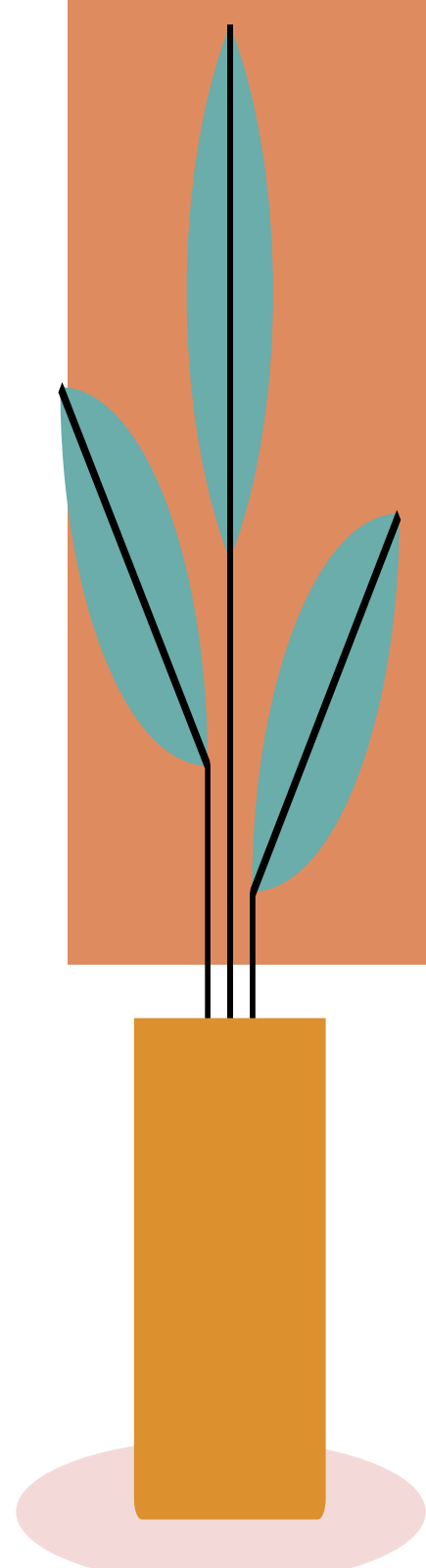
Respiratory distress

Renal failure

DIC Bc the cells are dying releasing mediators and tissue factors and ultimately coagulation cascade will be activated leading to DIC + bone marrow suppression

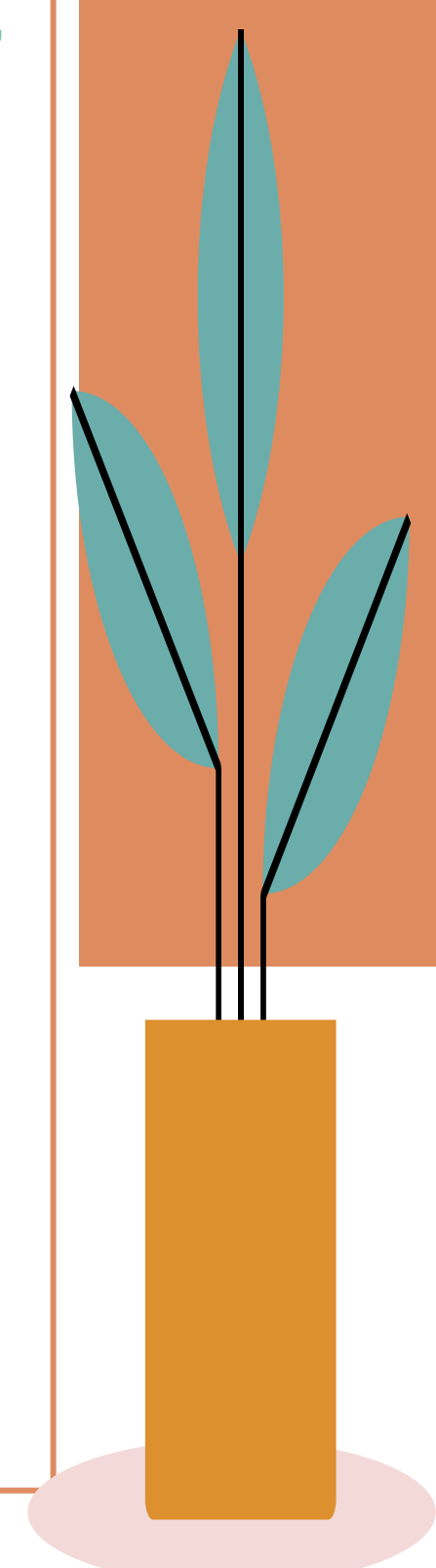
Disseminated  
Intravascular  
Coagulation

⇒ **Result is end organ failure** (thus management should be done immediately. Thus we need to resus the patient before any of these happen)



# Types of Shock: (Categorized based on which part of circulatory system fails)

<p><b>Low Cardiac Output states</b></p>	<p>CO is normal but Low peripheral resistance states (↑↑pipes) all vessels are dilated</p>
<p><b>Hypovolemic shock</b> (↓↓ solution -blood- pump is working with no blood)</p>	<p><b>Neurogenic shock</b></p>
<ul style="list-style-type: none"> <li>• Bleeding</li> <li>• Dehydration</li> </ul> <p>→ In dehydration, it's a low cardiac output state but the heart works fine. There is less blood volume to carry oxygen... as a result the mediators -as NE and hormones- will tell the heart to increase tropic volume and inotropy.the increase is up to a certain point then a shock might happen Symptoms are: tachycardia + increase SV + increase inotropy + cool temp + dry skin.</p> <p>→ The most common cause of hypovolemic hypoperfusion is hemorrhage</p>	<ul style="list-style-type: none"> <li>• Loss of sympathetic tone</li> </ul> <p>→ (complete loss of sympathetic tone that normally maintain some vasoconstriction)</p> <p>→ Remember: <b>Bradycardia and vasodilation are very characteristic of the neurogenic shock</b></p> <p>→ other clinical findings include: warm skin</p> <p>→ Loss of sympathetic tone also affects the heart, so the heart cannot compensate vasodilation</p> <p>→ <b>important: since both a neurogenic shock and a hemorrhagic shock can result from trauma always make sure your patient is not bleeding, treat as hemorrhagic shock after which take a step back and determine whether the patient is tachycardic or not? Bradycardia and warm skin indicate a neurogenic shock,</b></p>
<p><b>Cardiogenic shock</b> (↓↓ pump -heart-volume is intact but pump is not)</p>	<p><b>Vasogenic Shock</b></p>
<ul style="list-style-type: none"> <li>• Impaired inflow</li> <li>• Primary pump dysfunction</li> <li>• Impaired outflow</li> </ul> <p>→ In cardiogenic shock, the heart fails because of MI or HF ...etc.</p> <p>Blood volume is ok but the heart is having a problem. We will notice blunted heart response to stimulation mediators as NE and epinephrine</p> <p>→ The patient might be tachycardic (or even bradycardic) but with echo we find that stroke volume is low... some sick hearts can increase the rate but cannot increase the volume</p> <p>Some patients will inter bradycardia in late stages since the heart is too sick to compensate with tachycardia.</p> <p>→ clinical findings include: tachycardia, vasoconstriction, cold clammy skin, systemic vascular resistance will be high.</p>	<p>The heart is fine but the problem is in the vessels. the heart need to push through all of that. Some hearts can compensate by tachycardia, but if the heart wasn't able to compensate (as in old age people) then shock might happen.</p> <ul style="list-style-type: none"> <li>• Septic (Bacteria-&gt; toxins-&gt; cell damage-&gt; release of cell mediators thus causing uncontrolled vasodilation and leakage)</li> <li>• Anaphylactic (a lot of histamine is produced which causes vasodilation)</li> </ul> <p>Clinical findings: low peripheral vascular resistance, heart is intact</p>



# Types of Shock:

Shock type	Examples	HR	BP	CO	Capillary refill	Extremity temperature	SVR	Treatment
Hypovolemic	Hemorrhage Dehydration	↑	↓	↓	Delayed	Cool	High	Stop bleeding Fluid resuscitation
Cardiogenic	Myocarditis Dysrhythmia	↑	↓	↓	Delayed	Cool	High	Inotropes Caution with fluids ECMO
Distributive	Sepsis Anaphylaxis	↑	↓	↓ or ↑	Flash or delayed	Warm or cool	Low or high	Antibiotics, fluids Epinephrine
Neurogenic	Spinal cord injury Traumatic brain injury	↓	↓	↓	Flash or normal	Warm	Low	Fluid resuscitation Vasopressors
Obstructive	Tamponade Tension pneumothorax	↑	↓	↓	Delayed	Cool	High	Pericardiocentesis Chest tube
Dissociative	Carbon monoxide Cyanide	↑	Normal or ↑	↑	Normal	Normal	Low to normal	Antidotes Hyperbaric therapy

HR, heart rate; BP, blood pressure; CO, cardiac output; SVR, systemic vascular resistance.

You have to know how to diagnose the shock based on hemodynamic parameters

- As long as the cardiac output is low, the body will prioritize the brain and kidney (important organs) ... it will shunt the blood to brain and kidney which causes decrease in temperature, dry skin, and delayed capillary refill
- in distributive shock (also called vasogenic shock -including sepsis and shock) cardiac output may increase or decrease. It decreases in cases when the heart is fatigued of too much stimulation or when the heart itself is a part of the problem. E.g. if the heart is the source of infection that caused sepsis. when the heart is fatigued of too much stimulation
- In neurogenic shock if the pt is tachycardic it doesn't indicate neuro shock because the sympathetic nerves are not reaching both the heart and the vessels.
- In dissociative shock, everything is fine except hemoglobin
- Bp could be normal in early shock or a low in comparison to patient's own readiness. :eg, a patient who has been living with a Blood pressure of 170 than came to the ER with a BP of 110 is normotensive however a decrease of over 60 is considered significant and leads to the patient being hypotensive in his case.

## Classes of Hypovolemic Shock:

What this schedule is trying to say:

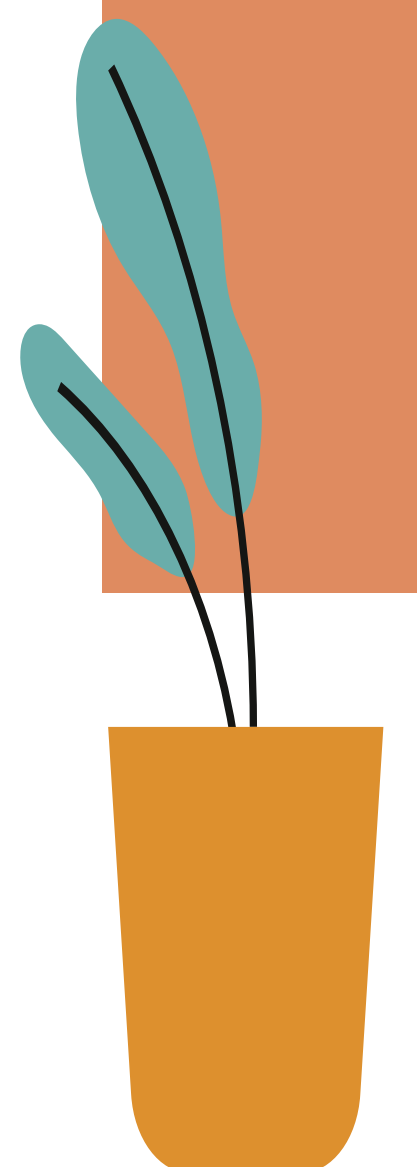
- Four classes depending on blood loss
- The more blood loss the more symptoms
- We shouldn't rely on reading patient's blood pressure because hypotension is a late finding

The doctor says he usually don't ask about classes of shock and he believes this schedule is not correct but we might get a question... also in International exams as USMLE they do ask about this

	I	II	III	IV
Blood loss (mL)	Up to 750	750-1500	1500-2000	> 2000
Blood loss (% blood volume)	Up to 15	15-30	30-40	> 40
Pulse rate (per minute)	< 100	100-120	120-140	> 140
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure (mm Hg)	Normal or increased	Decreased	Decreased	Decreased
Respiratory rate (per minute)	14-20	20-30	30-40	> 35
Urine output (mL/hour)	> 30	20-30	5-15	Negligible
Central nervous system/ mental status	Slightly anxious	Mildly anxious	Anxious, confused	Confused, lethargic

\* Pulse pressure = stroke volume = inotropy

\*Note that BP starts to dec in advanced classes (III, IV)  
 \*mental status deteriorates very early because the brain is very sensitive to O<sub>2</sub>  
 \*we check for reduced O<sub>2</sub> supply in end organs such as kidney and brain by ordering their respective function tests.



# Treatment of Shock:

- Goal: Restore perfusion with fluid, inotropes and vasopressors.
- Method: Depends on type of Shock
- Reverse the cause. e.g. if someone has an infection that caused septic shock, it's not enough to restore BP... you have to treat the infection

## Endpoints of Resuscitation in Shock management:

(how to know if we managed shock? In short, the best indicator is vital organ perfusion)

- Normal vital signs (can be misleading) remember: normal heart rate and normal blood pressure does NOT indicate the absence of a shock so we need to follow other markers that tell you about the organ damage and the 1st thing we check for is urine output!
- One of the worst things we can do as doctors is to miss signs of confusion, even if vital signs are relatively normal. Always check for confusion especially in elderly.
- Normal serum lactate levels
- Evidence of adequate tissue perfusion!! (esp. vital organs)
  - normal mental status
  - normal urine output (BEST marker, If a person was in shock and now the kidney filters normal amount (about 100cc/h) then I managed him well)
  - normal liver function. Etc...
  - normal lactate if it was originally elevated.

For lactate Note that:

1. Normal serum lactate does not always indicate the absence of shock, but elevated serum lactate indicates a problem that might be shock
2. When splanchnic circulation doesn't have enough perfusion so it produces lactate (because of ischaemic tissue)
3. Lactate isn't the best marker also because In some situations of shock, cells are too sick to produce anaerobic metabolism, so we won't find elevation of lactate

## Hypovolemic Shock Management

- ABCs

- Establish 2 large bore IVs or a central line

- Crystalloids

Normal Saline or Lactate Ringers

- PRBCs

O negative or cross matched

- Control any bleeding

Arrange definitive treatment

# Evaluation of Hypovolemic Shock:

- CBC
  - ABG/lactate
  - Electrolytes
  - BUN, Creatinine
  - Coagulation studies
  - Type and cross-match
- As indicated
- CXR
  - Pelvic x-ray
  - Abd/pelvis CT
  - Chest CT
  - GI endoscopy
  - Bronchoscopy
  - Vascular radiology

## IV Resuscitation:

### Flow Rates in IV/IO Access

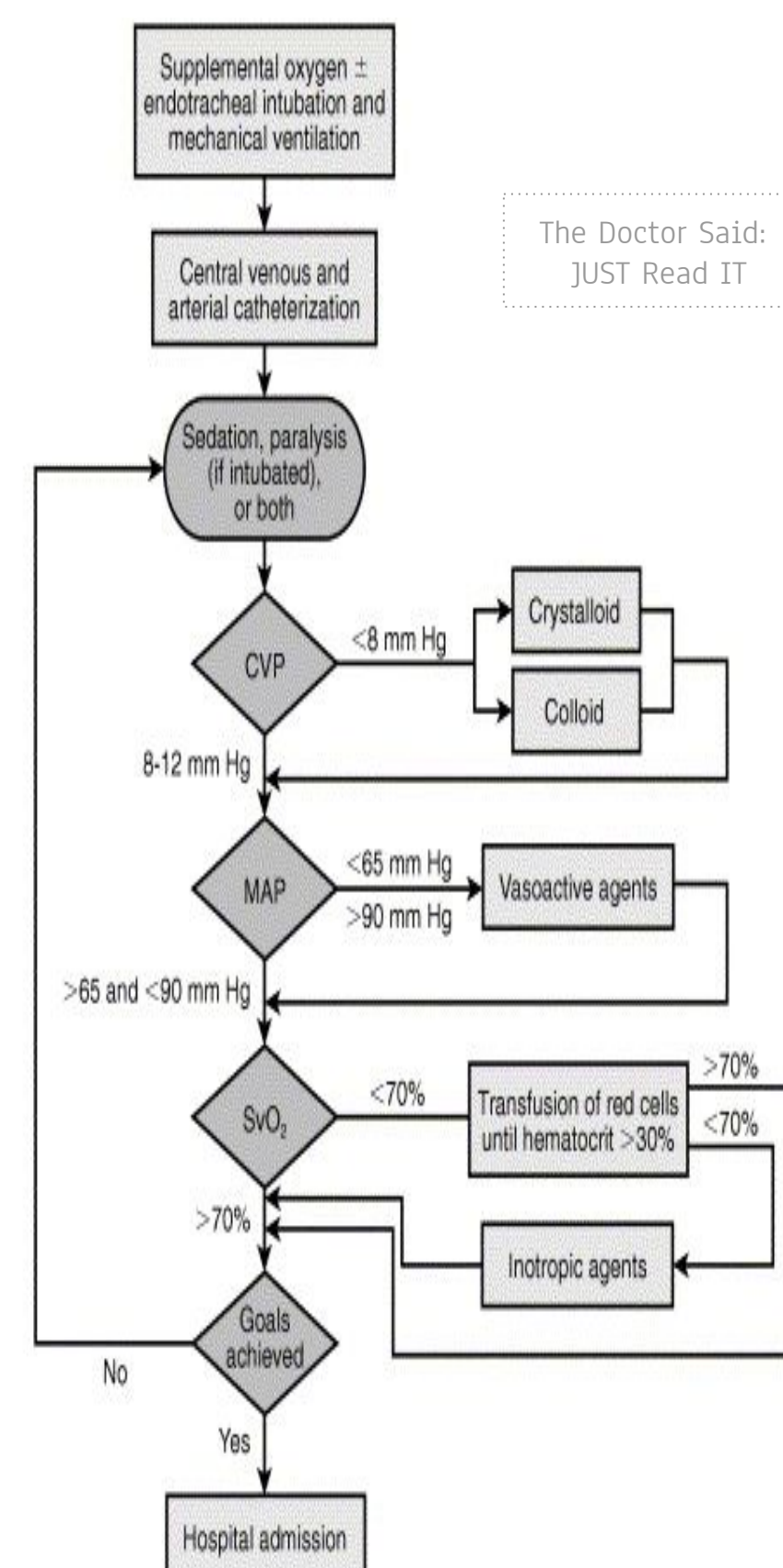
Gauge	Approximate Flow Rate to Gravity (mL/min)	Time to Infuse 1L (min)
14G	250	4
16G	150	7
Cordis	130	8
18G	100	10
15G Humeral IO	80	13
16G Distal Port Triple Lumen	70	15
15G Tibial IO	70	15
20G	60	17
22G	35	29
18G Prox Port Triple Lumen	30	34



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Anaphylactic Shock	Diagnosis	<ul style="list-style-type: none"> <li>● Clinical diagnosis (Defined by <b>airway compromise</b>, hypotension, or involvement of cutaneous, respiratory, or GI systems).</li> <li>● Look for exposure to drug, food, or insect</li> <li>● Labs have no role</li> </ul>
	Treatment	<ul style="list-style-type: none"> <li>● ABC's</li> <li>● Angioedema and respiratory compromise require immediate intubation</li> <li>● IV, cardiac monitor, pulse oximetry</li> <li>● IVFs, oxygen</li> <li>● <b>Epinephrine</b></li> <li>● Second line: Corticosteroids</li> <li>● H1 and H2 blockers</li> </ul>
Septic Shock	Treatment	<ul style="list-style-type: none"> <li>● 2 large bore IVs, fluid resus.</li> <li>● Supplemental oxygen</li> <li>● <b>Broad spectrum IV antibiotics, based on suspected source, as soon as possible.</b></li> <li>● Goal directed therapy.</li> </ul>

## Treatment Algorithm:



# Cases

## What Type of Shock is This?

- 68 yo M with hx of HTN and DM risk factors for intra abdominal bleeding presents to the ER with abrupt onset of diffuse abdominal pain indicates possible bleeding into the abdomen with radiation to his low back. The pt is hypotensive shock. tachycardic, afebrile, cannot be anaphylactic or septic with cool but dry skin. Vasoconstriction is functional.

### Hypovolemic shock (there is evidence of blood shunt)

- A 34F presents to the ER after dining at a restaurant where shortly after eating the first few bites of her meal, became anxious, diaphoretic, began wheezing, noted diffuse pruritic rash, nausea, and a sensation of her "throat closing off". She is currently hypotensive, tachycardic and ill appearing.

### Anaphylactic shock (history is the most important)

Note that in all shock types you won't find bronchospasm unless if it was an anaphylactic shock

- A 73 year old lady with a history of ischemic heart disease, HTN, DM II presents to the ED with altered mental status. She is febrile to 39.4, hypotensive with a widened pulse pressure, tachycardic, with warm extremities and decreased urine output.

### Septic Shock

#### Hypovolemic shock management:ABCs

Airway,Breathing, Circulation

Evaluation of hypovolemic shock :

Gi endoscopy: indication: hematemesis

Bronchoscopy: indication: hemoptysis.

Iv resuscitation

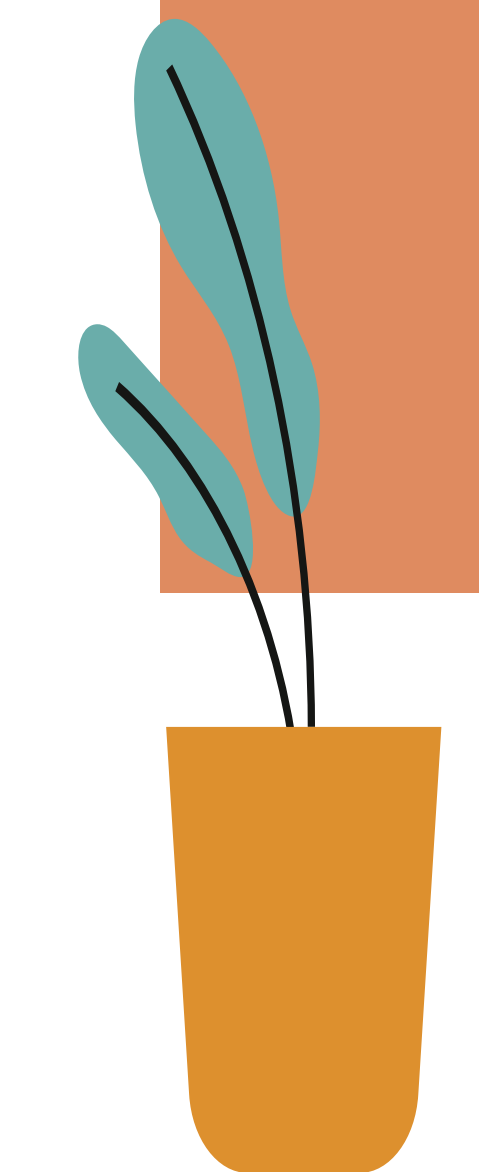
Why do we use 2 large bore iv? Because it is the best option, it can transfuse up to 2L in 4 min.using a central line will yield 1 L in 30 min.( not preferable)

While using a 14g yields 1L in 4 min.

Treatment of septic shock;

- Why do we give fluid initially? Due to leakage of fluid ( functional hypovolemia) ;even though the patient is edematous and swollen there is no fluid in the intravascular compartment.

- most important step is start with antibiotics.





# Summary

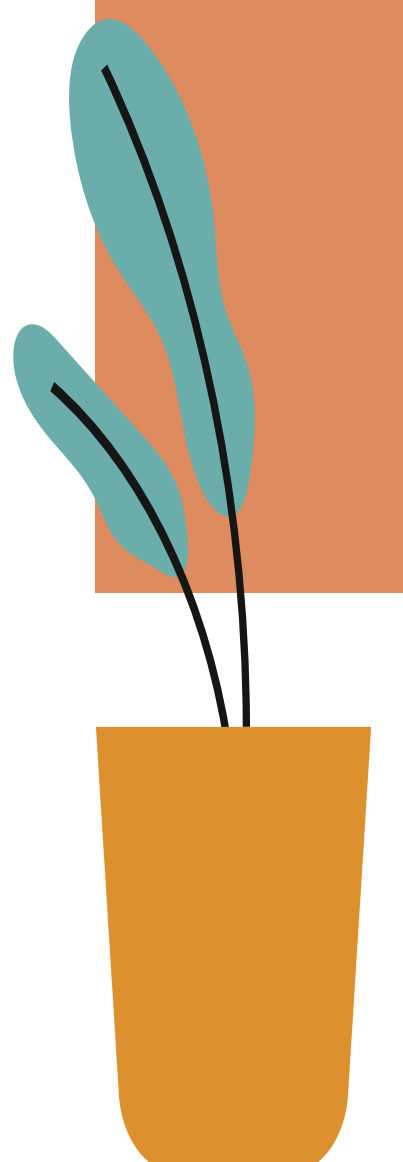
- Shock is inadequate tissue oxygenation.
- Can be a result of a variety of conditions.
- First step in management is to detect patients in shock.
- Management is mainly reversing the cause, while supporting vital functions in the meantime.
- If left untreated, will lead to death.

## Types of Shock:

Low Cardiac Output states	Low peripheral resistance states (↑↑pipes)
Hypovolemic shock (↓↓ solution )	Neurogenic shock
<ul style="list-style-type: none"><li>● bleeding</li><li>● Dehydration</li></ul>	<ul style="list-style-type: none"><li>● Loss of sympathetic tone</li></ul>
Cardiogenic shock (↓↓ pump )	Vasogenic Shock
<ul style="list-style-type: none"><li>● Impaired inflow</li><li>● Primary pump dysfunction</li><li>● Impaired outflow</li></ul>	<ul style="list-style-type: none"><li>● Septic</li><li>● Anaphylactic</li></ul>

## Treatment of Shock:

- Goal: Restore perfusion with fluid, inotropes and vasopressors.
- Method: Depends on type of Shock
- Reverse the cause. e.g. if someone has an infection that caused septic shock, it's not enough to restore BP... you have to treat the infection



# Quiz

1- 15-year-old s/p trampoline injury with tetraplegia (a.k.a. "quadriplegia") with hypotension. No other injuries on CT scans. It is presentation of which type of shock?

- a- Hypovolemic shock
- b- Septic shock
- c- neurogenic

2- which one of the following types of shock is associated with low peripheral resistance states .

- a- Cardiogenic shock
- b- anaphylactic shock
- c- Hypovolemic shock

3- 17 year old male. Training for track team. Vital signs: BP: 70/50 (low), Pulse rate : 140 (high), Respiratory rate 35 (high) O2 saturation : 88% Physical examination : absent breath sounds in L lung field, distended neck veins DX: tension pneumothorax Hemodynamics: Central venous pressure: Increased \ Cardiac output: Decreased \ Systemic vascular resistance: Normal .

- a- Neurogenic shock
- b- Septic shock
- c- Cardiogenic shock
- d- Hypovolemic shock

4- A 25 y/o driver sustained a car accident presented to the ER with flaccid paralysis, bradycardia, and hypotension. The most likely Dx:

- a- Neurogenic shock.
- b- Cardiogenic shock.
- c- Hypovolemic shock.
- d- None of the above.

5-The commonest cause of the previous case is:

- a- Massive external bleeding.
- b- Ischemic heart disease.
- c- Injury to the high thoracic spine.
- d- Internal bleeding.

Answers:

1:c 2:b 3:c 4:a 5:c

